NISTTech

ChemNose -Micro-Hotplate Devices and Methods for Their Fabrication

Low-power, accurate electronic olfactory 'nose' suitable for a wide range of applications

Description

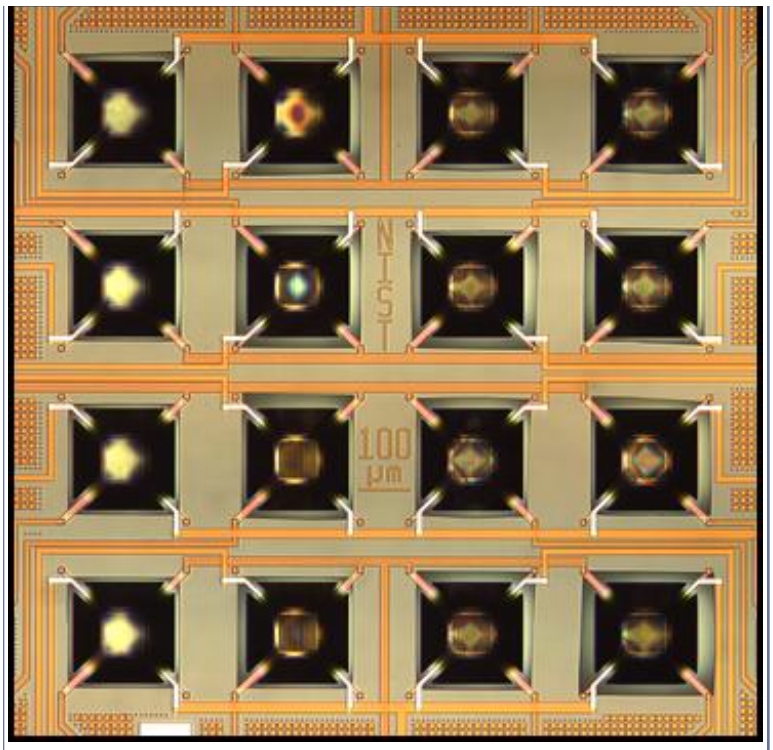
Combining a sensitive detector technology capable of distinguishing hundreds of different chemical compounds with a pattern-recognition module that mimics the way animals recognize odors results in a new approach for "electronic noses." ChemNose is adept at recognizing molecular features even for chemicals it has not been trained to detect and is robust enough to deal with changes in sensor response that come with wear and tear. The tunability of the new approach means that a variety of chemical warfare agents and toxic industrial chemicals in air-based backgrounds can be detected despite challenging interferences. New signal analysis schemes hold the potential for properly classifying "unknowns."

Among the attractive features inherent in ChemNose are small size (individual device structures are ~100 microns square, and unpackaged arrays fit on a 1 mm × 1 mm chip), low power consumption (battery operation), and tunability. Since it is fabricated through CMOS-compatible silicon technology, electronics can be added to enhance operational signal handling architectures and lower unit costs. Ease of integration and CMOS- compatibility aids coupling telemetry with the microsensors - thereby enabling network deployment. In addition, its robustness against the effects of sensor drift will facilitate its commercialization across a broad range of applications.

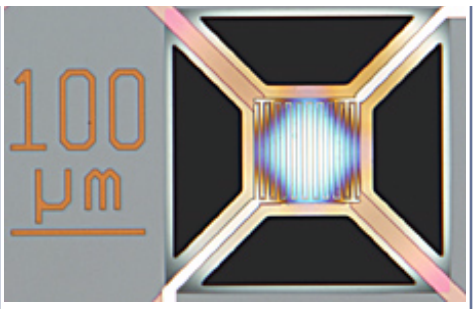
ChemNose is based on interactions between chemical species and semiconducting sensor materials placed on top of MEMS microheater platforms developed at NIST. Eight types of sensors in the form of oxide films are deposited on the surface of 16 microheaters, with two copies of each material. Precise control of each of the individual heating elements allows each to be treated as a collection of virtual sensors at 350 temperature increments between 150 to 500 deg C, thus increasing the sensor number to ~ 5,600. The combination of sensing films and the ability to vary the temperature gives the device the analytical equivalent of a snoot full of sensory neurons.

See related dockets under Citations: Nist Dockets 92-046, 92-047, and 96-047

Images



Close up of the sensor Credit: NIST



Possible applications include sniffing out nerve agents, environmental contaminants, and trace indicators of disease, in addition to monitoring industrial processes and aiding in space exploration. Credit: NIST

Applications

- **First Responders**
  Ideal for emergency response teams at possible chemical spill sites
- **Chemical processing and transportation**
  Useful as a primary alert for potential exposure to numerous toxic industrial chemicals and chemical warfare agents
- **Homeland security**
  Identifies the presence of many dangerous chemicals and can classify lesser known substances

Advantages

- **Portable**
  Compact design of approximately 100 microns square
- **Network capable**
  Add CMOS-compatible and additional electronics directly to the chip for easy integration
- **Low power**
  Battery operated
- **Autonomous**

"All-in-one" design does not require additional components

- **Adaptable**
  Capable of classifying "unknown" chemical compounds in addition to being able to pin point specific chemical warfare agents and toxic industrial chemicals

Abstract

A design and fabrication methodology, for silicon micromachined micro-hotplates which are manufactured using commercial CMOS foundries techniques with additional post-fabrication processing. The micro-hotplates are adaptable for a host of applications. The methodology for the fabrication of the micro-hotplates is based on commercial CMOS compatible micromachining techniques. The novel aspects of the micro-hotplates are in the design, choice and layout of the materials layers, and the applications for the devices. The micro-hotplates have advantages over other similar devices in the manufacture by a standard CMOS process which include low-cost and easy integration of VLSI circuits for drive, communication, and control. The micro-hotplates can be easily incorporated into arrays of micro-hotplates each with individualized circuits for control and sensing for independent operation.

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Citations

1.
   - ***Docket Number:*** 92-046
     U.S. Patent # 5,345,213
   - ***Docket Number:*** 92-047
     U.S. Patent # 5,356,756
   - ***Docket Number:*** 96-047
     U.S. Patent # 6,095,681
2. S Semanck and R. Cavicchi. Kinetically Controlled Chemical Sensing Using Micromachined Structures. Acc. Chem Res. 1998, 31, 279-287.
3. B Raman, J. Hertz, K.D. Benkstein, and S. Semancik. Bioinspired Methodology for Artificial Olfaction. Anal. Chem. 2008, 80, 8364-8371.
4. B. Raman, D.C. Meier, J.K. Evju, S. Semancik. Designing and Optimizing Microsensor Arrays for Recognizing Chemical Hazards in Complex Environments. Sensors and Actuators B: Chemical. 2009, 137, 617-629.

5. D.C. Meier, J.K. Evju, Z. Boger, B. Raman, K.D. Benkstein, C.J. Martinez, C.B. Montgomery, S. Semancik. The Potential for and Challenges of Detecting Chemical Hazards with Temperature-Programmed Microsensors. Sens. Actuators, B, 2007, 121(1), 282-294.
6. S. Semancik, R.E. Cavicchi M.C. Wheeler, J.E. Tiffany, G.E. Poirier, R.M. Walton, J.S. Suehle, B.Panchapakesan, D.L. DeVoe. Microhotplate Platforms for Chemical Sensor Research. Sensors and Actuators B Chemical. 2001, 77(1-2), 579-591.

Related Items

- Article: Sniffing Out a Better Chemical Sensor
- Article: Microsensors Sniff Out Gases
- Article: Designing an Ultrasensitive "Optical Nose" for Chemicals
- MERWYN Business Simulation Report

References

- U.S. Patent # 5,464,966
- Docket: 92-045US

Status of Availability

This invention is available for licensing.

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